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61-4-5  
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Now 61-0161-c (FBM)  
TASKS 1 & 2  
JULY, 1961  
DM 61-252

**Fabrication of Pyrolytic  
Graphite Rocket  
Nozzle Components**

**BUREAU OF WEAPONS**

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**FLIGHT PROPULSION LABORATORY DEPARTMENT**

**GENERAL  ELECTRIC**

August 8, 1961  
DM61-252  
RNM #18

FABRICATION OF PYROLYTIC GRAPHITE  
ROCKET NOZZLE COMPONENTS

Progress Report for July 1961

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ABSTRACT

Progress made in the manufacture of pyrolytic graphite nozzle inserts under Tasks 1 and 2 of contract NOw 61-0161-c (FBM) is described in the monthly report for July.

Residual stresses in the subscale inserts remain a problem due to the thickness to radius of curvature ratios. Chances of completing these inserts successfully without cracks are still quite low. Emphasis therefore will be placed on completing full scale components under the remaining funds in the contract.

## INTRODUCTION

During the month of July, 1961 development efforts were performed by the General Electric Company on tasks 1 and 2 under contract NOw 61-0161-c (FEM). Task 1 involves the fabrication of sub-scale coated and "free standing" pyrolytic graphite test nozzle inserts. Task 2 involves the fabrication of full scale coated and "free standing" pyrolytic graphite Polaris A-3 components. The pieces to be fabricated on these two tasks are as follows:

### Task 1:

- Phase A: Six (6) inserts of three different throat diameters - half to be .075" pyrolytic graphite on ATJ graphite and the others to be .100" pyrolytic graphite on ATJ graphite (ABL).
- Phase B: Four (4) inserts of .075" pyrolytic graphite utilizing a "free standing" design with various backup materials for low pressure firings (ABL).
- Phase C: Five (5) inserts of .075" pyrolytic graphite utilizing a "free standing" design backed with the best of various materials evaluated in Phase B for high pressure firings (ABL).
- Phase D: Two (2) inserts of .075" pyrolytic graphite. The first inserts to be pyrolytic graphite on ATJ graphite. After the test firing the second to be made according to test results. (ARC)
- Phase E: Five (5) inserts of .060" pyrolytic graphite on ATJ graphite (ARC).
- Phase F: Three (3) inserts of pyrolytic graphite on ATJ graphite with various throat diameters (ARC).

Task 2:

- Phase A: Two (2) second stage full scale symmetrical Polaris A3 throat inserts, one with .100" "free standing" pyrolytic graphite backed with ATJ graphite, the other with .200" "free standing" pyrolytic graphite backed with ATJ graphite (AGC).
- Phase B: Six (6) pyrolytic graphite on ATJ graphite second stage Polaris A3 throat inserts (AGC).
- Phase C: Six (6) second stage full scale Polaris A3 throat inserts of .080" - .100" pyrolytic graphite. The first two to be pyrolytic graphite on ATJ graphite (semi-egg style design). The next two to be "free standing" design with suitable backup. The remaining two to be made according to test results (ABL).
- Phase D: Six (6) pyrolytic graphite on ATJ graphite flame shields for second stage Polaris A3 throat inserts (ABL).

### SUMMARY

Three furnace runs were made during the month of July. One of the parts, an ARC sub-scale insert is in final inspection and will be shipped the first week in August.

Redirection was received from Aerojet General Corporation stopping work on the asymmetrical version of the A3 Polaris first stage nozzle inserts. A new drawing was received during the month calling out a .200" "free standing" liner thickness with split graphite backup for second stage application. Discussions with AGC resulted in an agreement to modify the forward wrap-around portion of the liner and to fabricate one each of two thicknesses - .100" and .200". A drawing with these changes has been sent to AGC for approval.

## DESCRIPTION OF TASK I PROGRESS

### ABL

One run was made in an attempt to fabricate a "free standing" sub-scale liner. This part was unfortunately cracked in disassembly. The second attempt at fabricating a "free standing" liner backed with a MgO interface and castable graphite (modified C-6) is still progressing and should be completed early in August.

### ARC

The liner thickness on the ARC sub-scale inserts still appears to be marginal. Of the last two fabricated during July one was found to be cracked in much the same manner as previous nozzles while the other is sound and crack-free. This nozzle insert has been through all machining operations and final inspections and should be delivered to ARC during the first week in August.

Because of the complexity of the design of the "IRIS" inserts the possibility of producing one intact is very low. This design has been given a low priority in the deposition schedule to allow greater effort to be placed on fabricating full scale Polaris components.



# TASK I STATUS

<u>PHASE</u>	<u>PART DESCRIPTION</u>	<u>CONTRACTED COMPLETION DATE</u>	<u>STATUS</u>
A	Six pyrolytic graphite on ATJ sub-scale inserts (ABL)	April 11, 1961	Three inserts of .075" pyrolytic graphite have been shipped. Three of .100" type to be fabricated.
B	Four "free standing" pyrolytic graphite sub-scale inserts (ABL)		One liner backed with castable epoxy and shipped. One liner in process to be backed with MgO and modified C-6.
C	Five "free standing" pyrolytic graphite sub-scale inserts - based on results of Phase B (ABL)		Undefined.
D	Two pyrolytic graphite on ATJ "IRIS" inserts (ARC)	April 25, 1961	Cracking problem in exit section still not solved.
E	Five pyrolytic graphite on ATJ sub-scale inserts (ARC)		One part ready for shipment.
F	Three pyrolytic graphite on ATJ sub-scale inserts (ARC)		Undefined.

## DESCRIPTION OF TASK II PROGRESS

### ABL

Another attempt was made to fabricate a "free standing" Polaris A3 second stage liner with a modification in the deposition mandrel in an attempt to eliminate an anticipated machining problem. The small radius at the forward wrap around portion led to a circumferential crack in that area resulting in a scrapped part. It appears that this design should be modified if any reliability in manufacturing is going to be obtained.

The furnace run originally scheduled for July to make one of the new design throat liners was delayed and should be made next month.

### AGC

No further work on the A3 asymmetrical "free standing" liners is being done due to the redirection from Aerojet General Corporation. New drawings were received from AGC calling for a .200" "free standing" liner backed with split graphite. The thickness to radius ratio at the wrap around section with the .200" pyrolytic graphite thickness undoubtedly would lead to excessive residual stresses in that area based on past experience. It was therefore decided to modify the design to allow a thickness of .100" pyrolytic graphite and a much less severe radius. Drawings including these modifications have been made and sent

to AGC for their concurrence. Upon receipt of their acceptance of this modified design, furnace components will be fabricated and a trial run attempted.

# TASK II STATUS

<u>PHASE</u>	<u>PART DESCRIPTION</u>	<u>CONTRACTED COMPLETION DATE</u>	<u>STATUS</u>
A	Two second stage Polaris A3 "free standing" symmetrical pyrolytic graphite inserts (AGC)	(No Date)	Awaiting acceptance of design by AGC.
B	Six second stage Polaris A3 pyrolytic graphite on ATJ inserts (AGC)	January 9, 1961	Complete.
C	Six second stage Polaris A3 pyrolytic graphite inserts (ABL)	→	Two inserts of pyrolytic graphite on ATJ graphite (semi-egg style) have been produced. One has been shipped to the customer and the other is being held, disposition to be determined after test firing of the first.
D	Four pyrolytic graphite on ATJ flame shields for second stage Polaris A3 (ABL)	February 24, 1961	One flame shield has been shipped. Delivery of the remainder will coincide with delivery of the Phase C inserts.

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